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school of thinkers. They say that experience is the only teacher we have, and that long-continued, unbroken experience of a consequent uniformly following an antecedent is and must be the highest proof of a natural law.

"The statement is plausible, but fallacious. Not fallacious, however, on the grounds which Mr. Wharton defends, namely, that cause implies a Will capable of making and breaking a law. No such thing. Several weeks ago we discussed this question of a Will, and pointed out, that truth in its highest forms admits of no such notion.

"That there is a higher warrant for natural law than uniformity of sequence, than mere experience, comes from the nature of reason itself, and is capable of demonstration.

"A few examples will serve to show the difference between the empirical law—the result of observed sequences—and the theoretical necessity which is at the foundation of every real law of nature. The planetary motions were first correctly stated by Kepler, who derived them from the astronomical observations of Tycho de Brahe; but, though Kepler accurately laid down the law of these motions on experimental grounds, it was reserved for the intellect of Sir Isaac Newton to give these observations their true significance by demonstrating the force of gravity, by virtue of which the planetary motions are inevitable effects. On the other hand, we know by daily experience that sensations are consequent upon impressions on the nervous peripheries; but the law of this sequence remains the desideratum of psychology.

"A real law finds its absolute confirmation in the fact that it transcends experience; that no observation attests the full amount of validity which we know it to possess. Reason alone is its sanction, and not experience; on the contrary, experience rarely comes up to the demands of the law. Thus, no hand of man has ever drawn an absolutely perfect circle; imagination cannot picture one; yet we have many propositions, or laws of relation, about circles which have in them no mixture of error. The actual velocity of a falling body is in no instance directly as the mass and inversely as the square of the distance; but this very fact becomes the proof of the law, for, allowance made for retardations, the theoretical accuracy of the law is vindicated.

"The essence of every real law of nature is its *theoretical necessity*. Expressed in terms of thought, this is the *ens rationis*. Hence, the definition of Mill and Bain must be condemned as incomplete; that advocated by Wharton, who considers natural law an expression of the will of God, must (if that expression is used as in any way corresponding to human volition) be rejected as contrary to the very nature of law; and, in any case, the confusion of the three meanings of law, to-wit, conscious obligation, observed sequence, and theoretical necessity, should always be avoided by writers on jurisprudence, theology, or physics."

Cortical Brain Substance.

Dr. Brinton continues his psychological discussions in his journal for December 12, 1874, in the following remarks upon the "Cortical Brain Substance":

"The highest and the most obscure problem in physiology is the relation of molecular motion to psychic action. It would seem that at a certain point of progress the clue slips from the fingers of the investigator, and he becomes completely bewildered. Yet there is a potent attraction about this study readily understood, and this last year some positive advances have been made which deserve close attention.

"Starting from the general truth which lies at the basis of comparative anatomy, that the skull is a development of the vertebra, and that the activity of the brain is governed by the same laws and the same conditions of the organic mechanism which preside over the activity of the different segments of the spinal axis and medulla oblongata, Dr. Luys of Paris points out that every spinal as well as cerebral reflex process is composed of three successive periods intimately connected with each other; a period of incidence, an intermediate period, and a period of reflexion. The first is always an impression irradiated from a sensory plexus, a centripetal impression, conscious or unconscious, and marks the *début* of the whole phenomenon, and it is always an attendant or satellite motor reaction that completes it. In the brain, as in the spinal cord, there is a system of zones or cells disposed for the reception of centripetal impressions, and a system of zones disposed for the emission of motor excitations.

"Physiological research shows that it is in the networks of the cortical substance of the brain that sensory impressions of all kinds reach their ultimate stage, taking from this point a new form, and becoming transformed into psychical incitations, which again lead to movement. The networks of the cortical substance therefore represent a vast common reserve for all impressions belonging either to animal or to vegetable life, and, in a physiological point of view, a synthesis of all the partial sensibilities of the organ, i.e. the *sensorium commune*. On the other hand, the experiments of Flourens and Ferrier have shown that there exists in the cortical substance of the brain a series of isolated and independent motor centres governing certain groups of muscles. A cerebral reflex process differs from a spinal one in its being amplified and transformed by the proper action of the exclusively cerebral nervous element interposed in its course. Speech, for example, Dr. Luys explains, essentially results from the synergic action of the psycho-intellectual and of an automatic sphere of nervous activity, the former comprehending the affection of the sensorium and subsequently of the conscious individual, the latter embracing the integrated and co-ordinated translation of the sensorial excitation. Anatomically, this last commences in the deep zones or cells of the cortex of the brain, and is conducted through the whole cortical striated fibres, then through the gray substance of the corpus striatum and of the pons, and terminates in the nuclei of origin of the hypoglossal and spinal nerves, which convey the impulses to the muscles affecting phonation.

"The cells of the deep layers of the cerebral cortex, of which it is here question, are therefore the real seats of psychic action, and become of the utmost consequence in the study of its origin. They have recently been accurately examined by Prof. Betz. He finds in the convolutions anterior to the sulcus centralis numerous nerve cells which he considers to be the largest in the whole body, and to which he gives the name of 'giant pyra-

midal cells.' They are chiefly situated in the fourth layer of the cortex; are from .05 to .06 mm. broad and .04 to .12 mm. long. They all have two chief and from seven to fifteen secondary processes, and the latter further divide into still smaller ones. One of the principal processes is thick at its origin, and then divides and subdivides, and sends out lateral branches in its course to the periphery of the cortex; the other process is slender, and starts from the nucleus of the cell, passing directly into the axis cylinder, which soon becomes thicker and provided with a sheath, and so continues its course as an undoubted nerve-trunk.

"These cells do not form a continuous layer, but are aggregated into groups or nests of two or more cells, which lie from .03 to .07 mm. apart. They are less numerous in the lower half of the anterior central convolution, and are more frequently met with and more closely packed at its upper end and on the inner surface of the hemisphere. These nests occur in quite young people, though in them they are smaller and have fewer processes than in adults. In the brains of very old people the nuclei of the cells become filled with yellow granules, which do not stain with carmine. In the right hemisphere the cells are more numerous and apparently larger than in the left. They are to be found in the same locality in every human brain; in idiots, in the chimpanzee, and in several of the lower apes. Strictly analogous ones are found in the dog.

"There is no doubt but that these important elements are the central seats of psychic action. The only physiologist, so far as we know, who advocates any other is Nothnagel; and Dr. Hitzig, whose name is well known in this field of research, justly criticises Nothnagel's opinion that mental or spiritual functions cannot be rigidly localized in the brain cortex, holding that he reads the phenomena wrongly.

"Hitzig himself says: 'It follows from the sum of our experiments that thought is by no means, as Flourens and others have believed, a kind of general function of the brain, the expression of which may be made from it as a whole, but not from single regions; *but that it is much more certain that some psychological (seelische) functions, probably all of them, are dependent, either in their action on matter or their reflection from the same, on certain circumscribed cortical centres.*' And he adds: 'For the correctness of this view, in fact, is shown with all desirable logical clearness from our experiments, and we consider this truth as the most valuable result of our labors.'

"Not only, therefore, the cortex is the seat of thought, but certain regions of it correspond to definite mental functions. This, as our readers well know, has been ably maintained by Prof. Ferrier; and one of the last contributions of that writer, one entitled 'Pathological Illustrations of the Brain Function,' has a peculiar interest, as it is a practical application of its author's recent discoveries to the explanation of the facts of disease. Five fatal cases of organic disease of the brain are reviewed in it, and their symptoms are shown to have been in perfect harmony with the results of experimental inquiry.

"With all this effort, which is admirable *in suo genere*, there is not a tittle of light thrown on the problem which is stated at the commencement of this article. Any one who supposes there is, reads his text wrongly.

Certain conditions requisite to conscious thought are beginning to be defined. But what sort of relation these conditions bear to this manifestation, no one has discovered a single fact about. The causal law, the theoretical necessity, eludes us utterly."

Mind and Force.

Editor of the Journal of Speculative Philosophy :

I was much interested in the abstract which you gave, in the last number, of the views of Dr. Brinton on life, force, &c. The Doctor appears to be an anti-materialist; but he seems to me to allow too much weight to the second horn of his dilemma (p. 377) when he says, "All mental and physical force expended being exactly equal to the force in the form of nutriment received, clearly the mind, if there is any such independent thing, contributes *no* force at all. * * * This is demonstrable." If this is demonstrable, I, for one, would be obliged to Dr. B., or any other person, for a sight of the demonstration. I have read all I have had access to on this subject, and have yet to see the slightest shadow of proof of his statement. I have regarded it as founded wholly on a surmise of Dr. Carpenter: that, as the forces of inorganic nature can be reduced to a single formula, that formula may be extended to organic being. This idea has been caught up by physiologists, and repeated by one and another so often, that, as usually is the case with great story-tellers, they have to regard it as true. Efforts have indeed not been wanting to tabulate the forces which the movements of living beings display, but still they refuse to arrange themselves under the mathematical yoke. From the time that Dr. A. Flint, Jr., compared the amount of urea secreted by a man lying on his back in a hospital with that of a man taking severe exercise, and found little or no difference, to the time of the ascent of the Faulhorn by Wick and Wislicenus, every attempt to link the muscular energy expended with the food consumed, either by decomposition of the muscle itself, or by that of the elements of the blood, has been a failure. If there is a greater amount of carbonic acid evolved during muscular exertion than in a state of rest, there is a coëxistent activity of the nervous system which may, and in my opinion does, account for it. More is also evolved during the waking than in the sleeping state, irrespective of exercise. These facts, together with the consideration that the brain is the only organ of a single tissue to which the blood is sent arterial and returns venous in large quantity, implying that decomposition of the elements of the food which produces force; while the various secretions, as of the liver, kidneys, salivary glands, &c., are manifestly indifferent to it; and taking into view the effects of posture on syncope—the narcotization produced when the change from arterial to venous blood cannot take place—the *pari-passu* development of the arterial and nervous system in animal life, and the parallelism of their distribution throughout the body, point irresistibly to the vesicular tissue of the brain, spinal marrow, ganglions, and surfaces of sensation, as the seats where the changes are wrought by which the food becomes power, and there is every reason to believe that this power is expended on the nerves alone. And it may be added that this is the limit of machinery, or chemically formed power, in the human system. And the simple reason is, that such power cannot be made avail-